Soil Microbial Indicator tests in northern and north west Tasmania

Bill Cotching[1] and Doris Blaesing[2]

[1]Tasmanian Institute of Agricultural research
[2] RM Consulting Group

September 2008

Methods and analyses

Soil microbial indicator tests were carried out on 265 paddocks in the Cradle Coast region and Northern Midlands from September 2006 until April 2008. These tests were undertaken as part of the project 'What are we going to do about it?' Monitoring and implementing farmer based decisions for productive agriculture and sustainable land management' managed by Serve-Ag Pty Ltd and funded by the Australian Government National Landcare Program.

Tests were undertaken by DHM Labs (NZ) and included total microbiological count, bacteria count, fungi count, yeast count, anaerobic test, azotobacter, actinomycetes, fungi:bacteria, fungi:yeast, and viable count. Total microbiological count is a calculation of the sum of the bacteria, fungal and yeast counts. It is a viable (living) count generally 10 to 100x less than a microscope count. Bacteria count is a specific plate count following a peptone enrichment and extraction (Goodfellow 1968). Bacteria take up to 5 days to grow. A count of the colonies is then carried out. This figure indicates the aerobic bacteria population growing in the soil. Fungi count is a modified plate count using the Rose Bengal agar method (Martin 1950). Again an enrichment and extraction is carried out prior to the plate count to maximize the numbers of fungi that can be isolated. Additives are used to inhibit growth of the fungi so the individual colonies may be counted. Fungi take 5-7 days to culture. Yeasts are suppressed and identified on different media more beneficial to their isolation. This figure indicates the fungi population growing in the soil. Yeast count is a modified specific plate count using the yeast extract agar method (Allan 1957). The soil is enriched and extracted as above and yeasts are then isolated on agar and they take up to 5 days to grow up. This figure indicates the yeast population in the soil. Anaerobic test measures the bacteria and yeasts that grow without oxygen. The method was developed by Brewer in 1942. The soil is enriched and the bacteria extracted and plated on specific agar. These plates are then incubated in a non-oxygen environment for 5 days. Soil Activity Levels -Fluorescein Diacetate (FDA) This test comes in two parts. The first part measures the viable levels of the soil and the second part measures the non-viable levels. The first part is a modification (Waikato University) of the FDA staining method used for microscope counts. The enzymes present in the cells of the life of the soil breakdown the colourless compound FDA into fluorescen, (a florescent compound). The absorbance of this is then measured. The second part measures non-viable organisms including dead and dormant ones. It uses the Propidium Iodide (PI) method. Non-permanent dye penetrates the membrane of dead and dying cells. This reacts with the DNA and fluoresces a red colour, the absorbance of which is then measured. The result gives an indication of how biologically active the soil is (or its current potential). The greater the figure, the more active the soil is and the better the plant growth. When related to the total microbial count, it will give an indication of how effective the physical soil environment is to supporting the growth of microbe populations.

The data analysed was for when the data was recorded rather than when the samples were taken. Although this is unfortunate samples were analysed within 10 days after being taken and the data was entered within 3-4 weeks of the samples being taken. The crop

groupings analysed were pasture (73), potato (112) and cereals (barley, oats, rye, triticale, wheat - 32). Results from paddocks with poppies, onions, peas, carrots, lucerne, lupine, maize, pyrethrum and beans were also obtained but the numbers of analyses were too few for more rigorous analysis.

Results and discussion

The results were analysed in the knowledge that soil type, climate and plant type are all likely to influence the results. The Cradle Coast region samples were all taken on Ferrosols with clay loam topsoil textures, the climate is cool temperate being near the coast and most paddocks were irrigated. The Northern Midlands samples were likely to be dominated by duplex soils (Kurosols and Sodosols) with sandy loam topsoil textures, the climate is both cooler in winter and warmer in summer than the Cradle Coast and few of the paddocks were irrigated.

The Cradle Coast region had greater average total microbes, bacteria and yeast than the Northern Midlands in all crop types and lower average fungi:bacteria and fungi:yeast ratios under both cereals and pasture. However, not all these differences were statistically significant ($P<0.05$). Bacteria levels under pasture and yeast levels under both cereals and pasture were significantly greater in the Cradle Coast region than the Northern Midlands. Only the fungi:yeast ratio under cereals was significantly different between the two regions. Cereals had greater average total microbes, bacteria and fungi and less yeast than pasture in both regions. Potatoes had the highest level of fungi and the lowest yeast in Cradle Coast samples. Potatoes and other vegetables ideally have higher fungi levels than pastures. Grasses thrive better with higher bacteria:fungi ratios. No significant differences in anaerobic microbes were found. The standard errors indicate that there was considerable variability in the data and we have no associated soil physical and chemical data or crop yields to associate with, or provide an explanation for, particular results. This lack of explanatory variables must be kept in mind when advising on possible target levels for these soil microbial indicators. Values for the soil microbial indicator tests have been rounded for presentation in Table 2, as the degree of precision implied by the values in Table 1 is not warranted.

Table 1. Soil microbial indicator test results.

	Microbial biomass (kg/ha)					Microbial ratios	
	Total Microbes	**Bacteria**	**Fungi**	**Yeast**	**Anaerobic**	**Fungi:Bacteria**	**Fungi:Yeast**
Cereals Cradle Coast	12324 (1361)	5020 (614)	3732 (628)	3571 (353)#	387 (144)	1.6 (0.17)	1.0 (0.11)#
Pasture Cradle Coast	11998 (674)*	4815 (298) #	3654 (380)	3753 (308)#	228 (33)	1.7 (0.16)	1.5 (0.23)
Potatoes Cradle Coast	11823 (458)	3926 (192)	5314 (405)	2584 (90)	561 (72)	2.5 (0.17)	2.5 (0.35)
Cereals northern Midlands	11330 (1058)	3798 (236)	5649 (905)	2063 (162)#	124 (29)	2.0 (0.23)	2.7 (0.43)#
Pasture northern Midlands	10653 (644)	3733 (179)#	4542 (478)	2375 (157)#	262 (56)	1.9 (0.13)	2.0 (0.18)

*(std error)

significant differences between regions (P<0.05)

Table 2. Soil microbial indicator tests with values rounded.

	Microbial biomass (kg/ha)					Microbial ratios	
	Total Microbes	**Bacteria**	**Fungi**	**Yeast**	**Anaerobic**	**Fungi:Bacteria**	**Fungi:Yeast**
Cereals Cradle Coast	12300	5000	3700	3600	390	1.6	1.0
Pasture Cradle Coast	12000	4800	3700	3800	230	1.7	1.5
Potatoes Cradle Coast	11800	3900	5300	2600	560	2.5	2.5
Cereals northern Midlands	11300	3800	5500	2100	120	2.0	2.7
Pasture northern Midlands	10700	3700	4500	2400	260	1.9	2.0

Seasonal microbial indicator data indicate that total microbes under pasture peak in the autumn-winter period. In the Cradle Coast region, total microbes under pasture peak in the autumn (Figure 1) whilst the peak occurs in winter in the Northern Midlands (Figure 2). This may be due to a combination of soil moisture and temperature conditions. Pastures in the Midlands were not irrigated and would have had higher soil temperatures than those in the North West. The dryland pastures were used for sheep grazing, while the irrigated pastures in the North West were used for dairying with somewhat higher fertiliser inputs. Under potatoes, there was little consistent seasonal trend and considerable variability in the total microbes, which was dominated by fungi levels (Figure 3). Bacteria levels under potatoes tended to increase over the warmer summer months and decrease over winter. This data must be considered as indicative only as not all paddocks were sampled on each occasion meaning that the mean result was for a different group of paddocks at each season. Results for the same paddocks show inconsistent trends when changing crops with a change from potatoes to pasture resulting in decreases, increases and in between values of total microbes (Figure 6).

Fungi:bacteria and Fungi:yeast ratios under pasture were least over summer and greater in autumn and spring (Figure 4). Fungi:bacteria and Fungi:yeast ratios under potatoes followed similar trends with low ratios in late summer and higher ratios in winter and spring (Figure 5). Results on the same paddocks with different crops found fungi:bacteria ratios under potatoes ranging from 0.4 – 6.1 with a following pasture or cereal ranging from 0.8 – 1.6 (Figure 6).

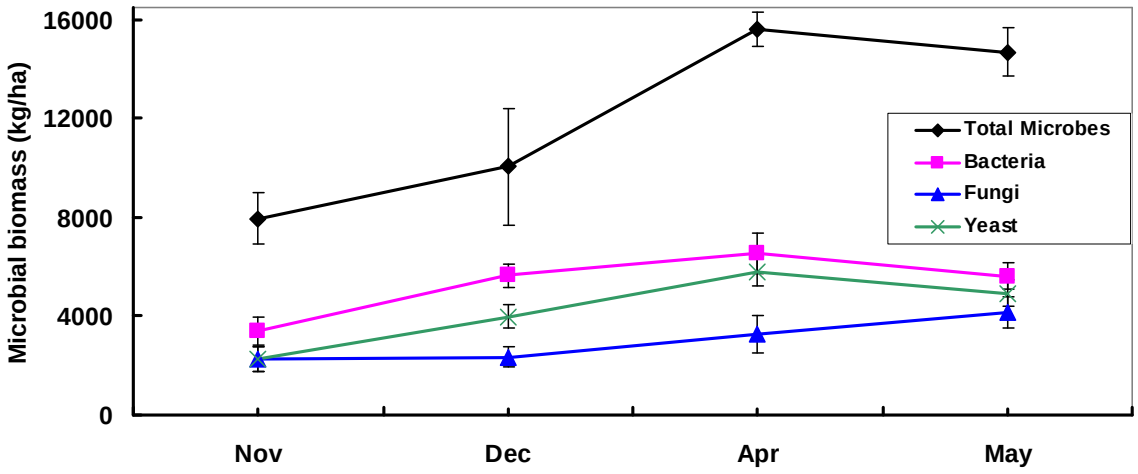


Figure 1. Microbial biomass under pasture in Cradle Coast region

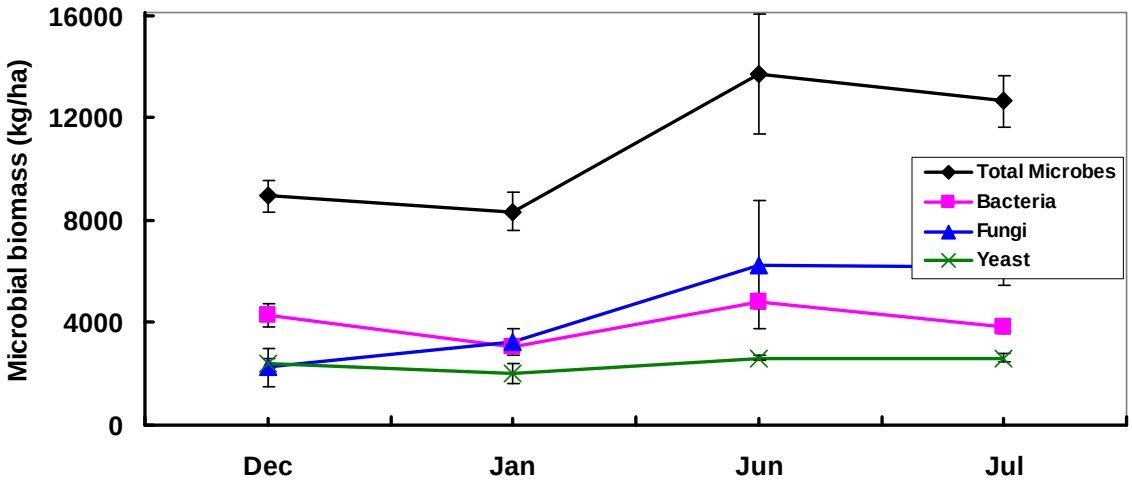


Figure 2. Microbial biomass under pasture in Northern Midlands

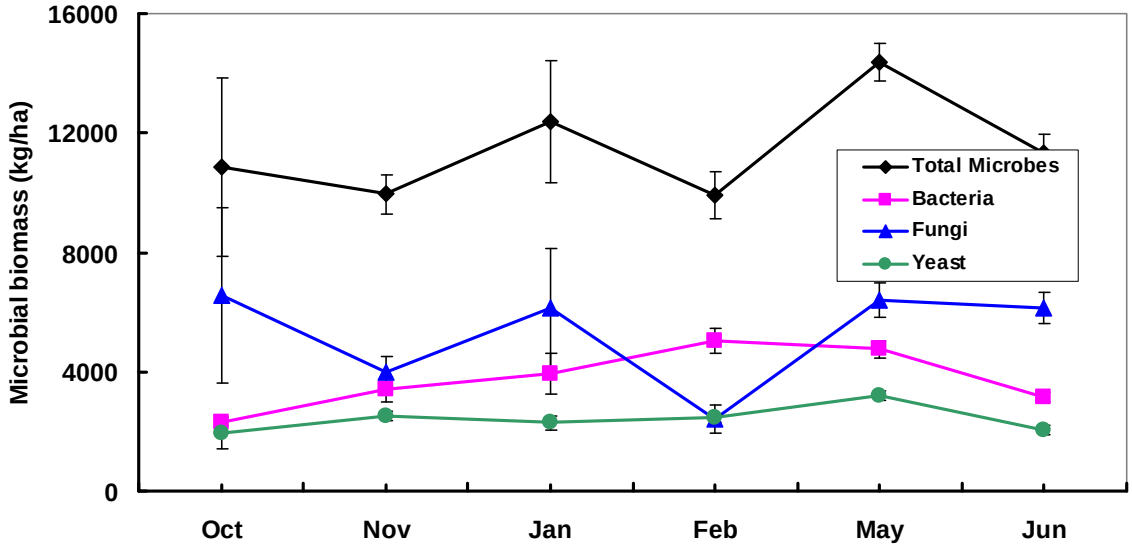


Figure 3. Microbial biomass under potatoes in Cradle Coast Region

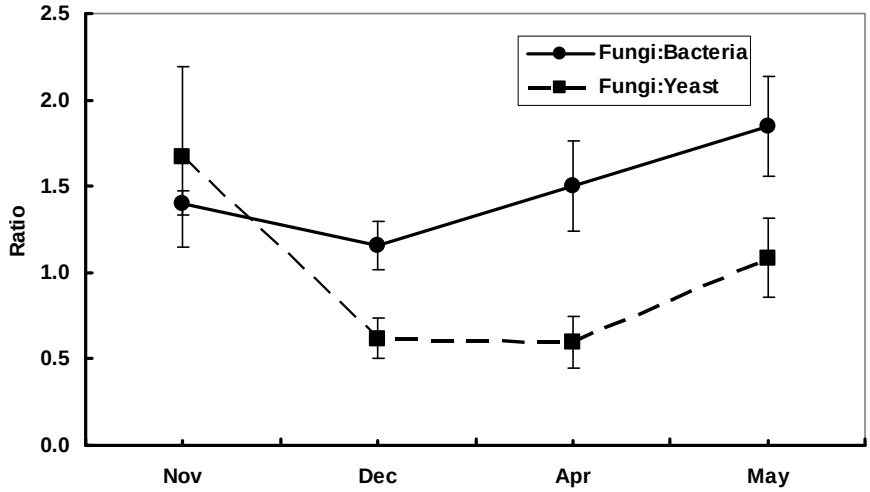


Figure 4. Microbial biomass ratios under pasture in Cradle Coast Region

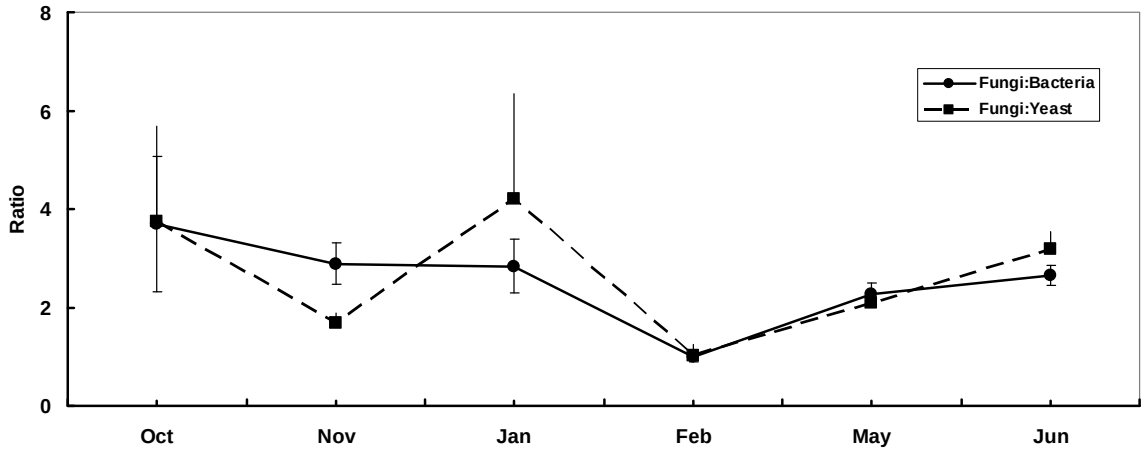


Figure 5. Microbial biomass under potatoes in Cradle Coast Region

Summary

Differences in soil microbial levels between the Northern Midlands and the Cradle Coast regions were found. Bacteria levels under pasture, yeast levels under both cereals and pasture, and the fungi:yeast ratio under cereals were significantly greater in the Cradle Coast region than the Northern Midlands. Cereals had greater average total microbes, bacteria and fungi and less yeast than pasture in both regions. Potatoes had the highest level of fungi and the lowest yeast levels compared to pasture and cereals. Total microbes under pasture peaked in the autumn-winter period. Under potatoes there was little

consistent seasonal trend and considerable variability in the total microbes which was dominated by fungi levels. There was considerable variability in the data, as indicated by standard errors, but no associated soil physical and chemical data were collected to provide an explanation for particular results or relationships to crop yields.

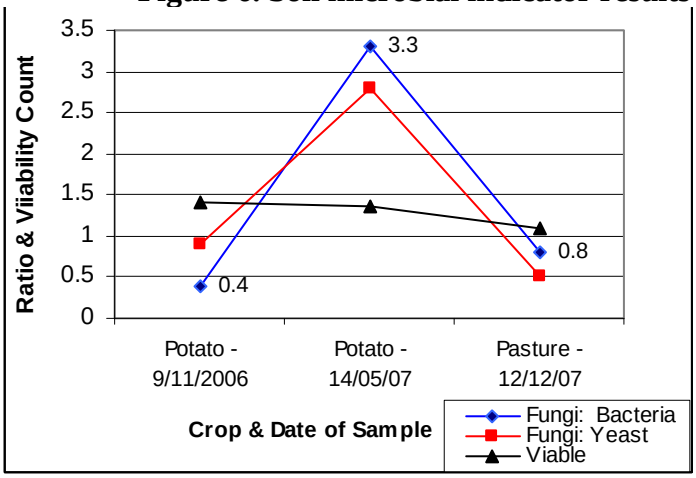
Conclusions

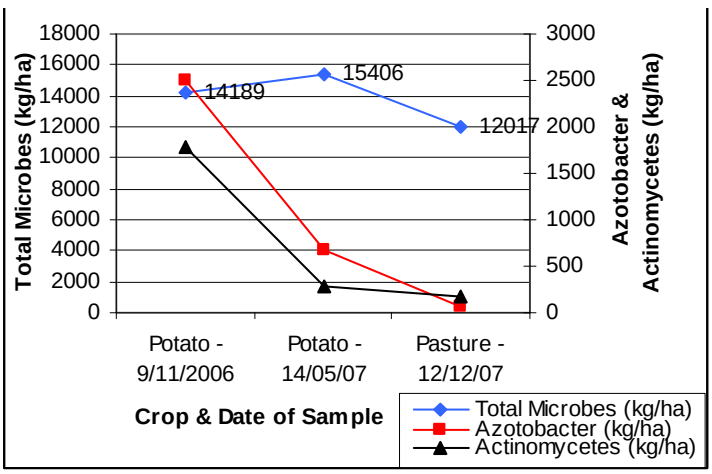
The soil microbial data provided information on some general trends and comparisons between soil types and crops. However, more supporting data on chemical and physical soil condition and crop performance is required to better understand the benefit of certain microbial levels and ratios.

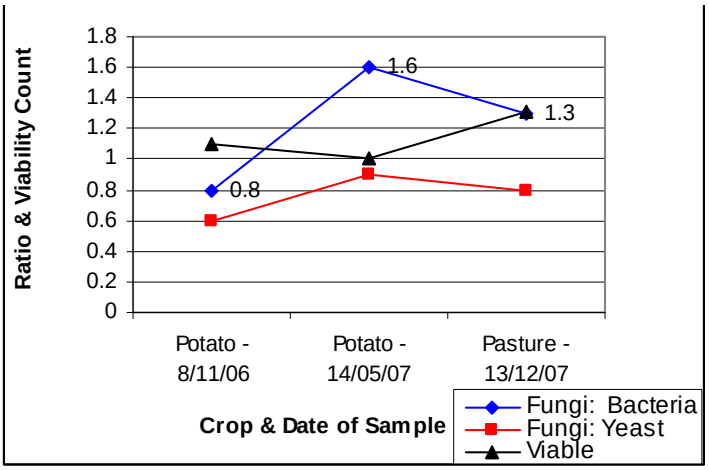
Acknowledgements

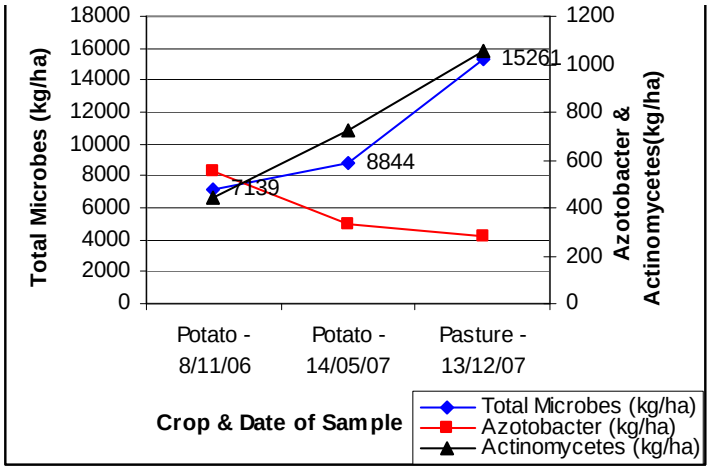
We want to acknowledge the efforts of Bronwyn Haller, Elizabeth O'Conor, Pam Skurulis and Kurt de Jong for taking and processing the soil samples and entering the data in a database.

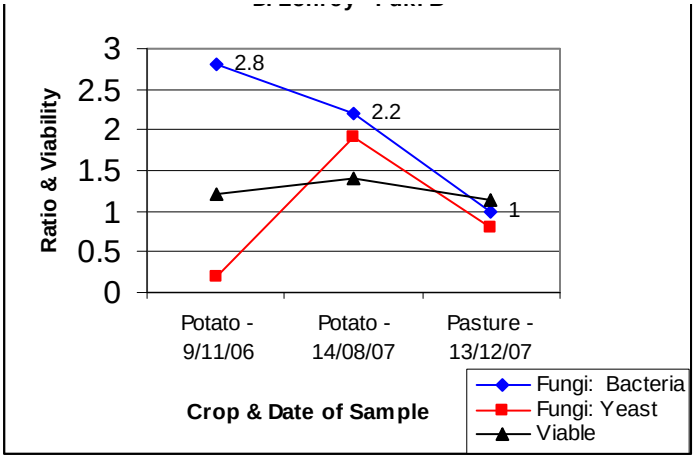
Figure 6. Soil microbial indicator results in northwest Tasmania.

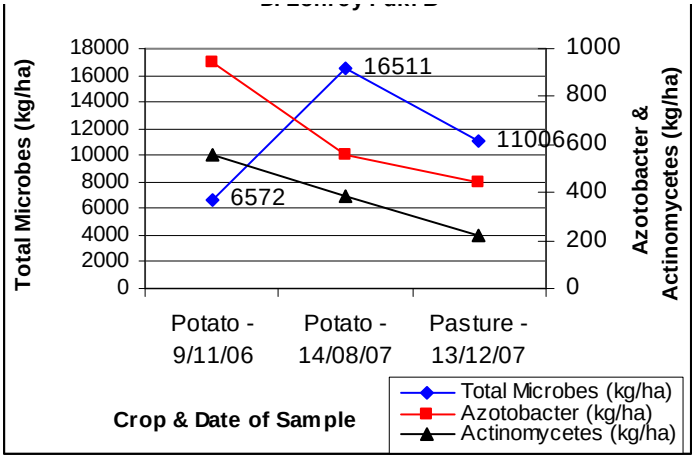


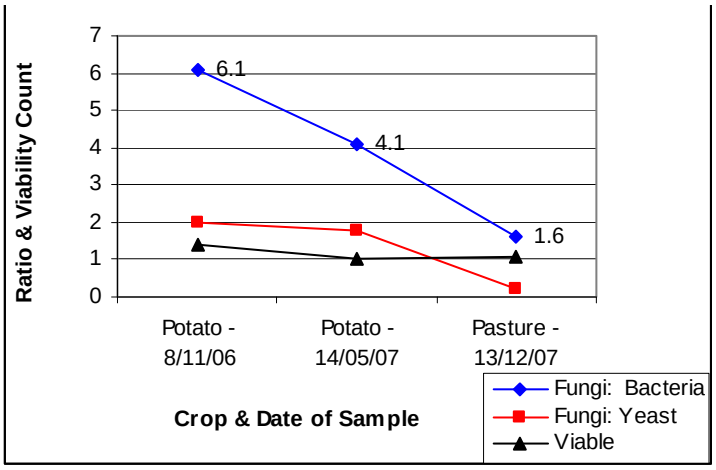


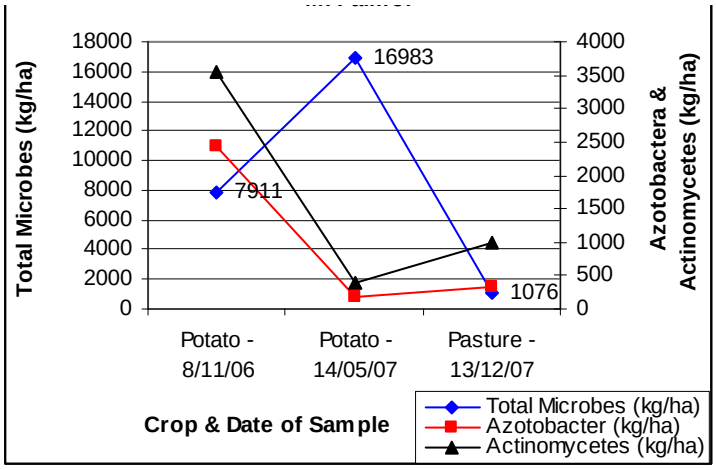


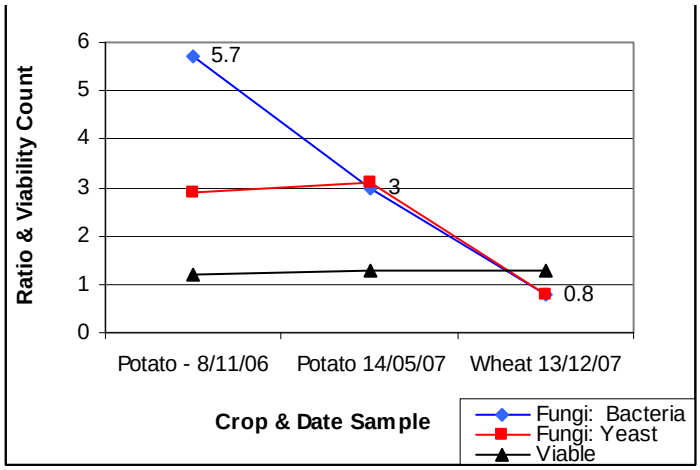


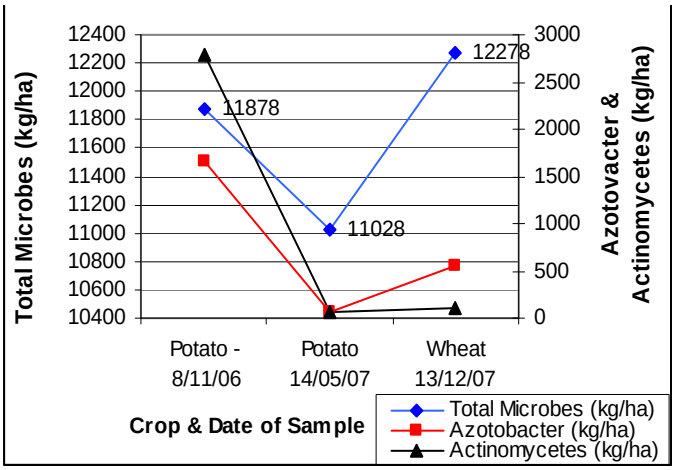


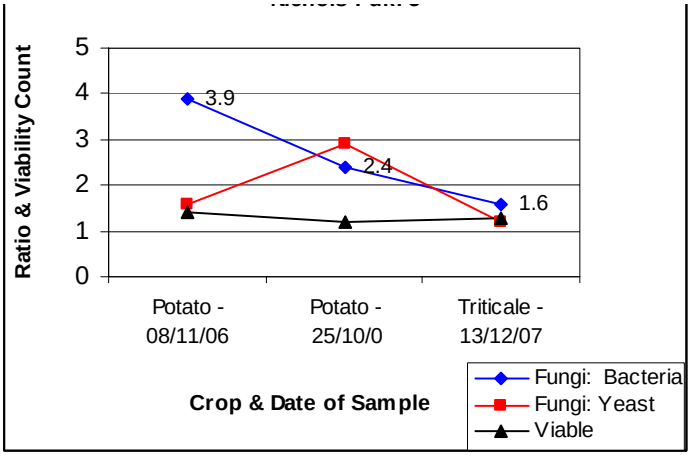


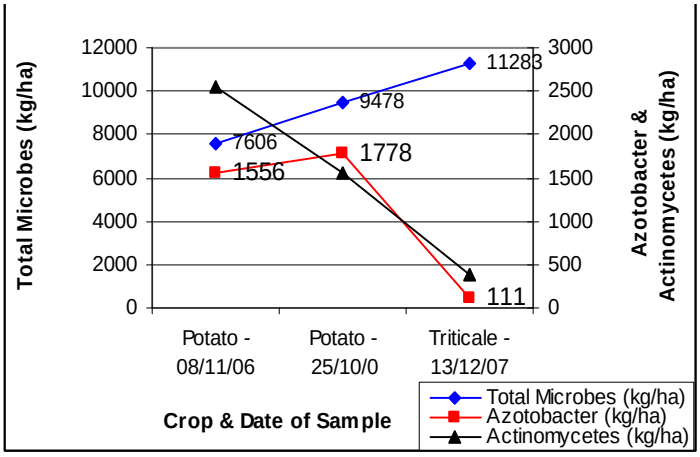

Ratio & Viability Count
7
6
5
4
3
2
1
0
6.1
4.1
1.6
Potato - 8/11/06
Potato - 14/05/07
Pasture - 13/12/07
Crop & Date of Sample
Fungi: Bacteria
Fungi: Yeast
Viable


Total Microbes (kg/ha)
18000
16000
14000
12000
10000
8000
6000
4000
2000
0
16983
7911
1076
4000
3500
3000
2500
2000
1500
1000
500
0
Azotobactera & Actinomycetes (kg/ha)
Potato - 8/11/06
Potato - 14/05/07
Pasture - 13/12/07
Crop & Date of Sample
Total Microbes (kg/ha)
Azotobacter (kg/ha)
Actinomycetes (kg/ha)


Ratio & Viability Count
6
5
4
3
2
1
0
5.7
3
0.8
Potato - 8/11/06
Potato 14/05/07
Wheat 13/12/07
Crop & Date Sample
Fungi: Bacteria
Fungi: Yeast
Viable


Total Microbes (kg/ha)
12400
12200
12000
11800
11600
11400
11200
11000
10800
10600
10400
12278
11878
11028
3000
2500
2000
1500
1000
500
0
Azotovacter & Actinomycetes (kg/ha)
Potato - 8/11/06
Potato 14/05/07
Wheat 13/12/07
Crop & Date of Sample
Total Microbes (kg/ha)
Azotobacter (kg/ha)
Actinomycetes (kg/ha)


Ratio & Viability Count
5
4
3
2
1
0
3.9
2.4
1.6
Potato - 08/11/06
Potato - 25/10/0
Triticale - 13/12/07
Crop & Date of Sample
Fungi: Bacteria
Fungi: Yeast
Viable


Total Microbes (kg/ha)
12000
10000
8000
6000
4000
2000
0
11283
9478
7606
1778
1556
111
3000
2500
2000
1500
1000
500
0
Azotobacter & Actinomycetes (kg/ha)
Potato - 08/11/06
Potato - 25/10/0
Triticale - 13/12/07
Crop & Date of Sample
Total Microbes (kg/ha)
Azotobacter (kg/ha)
Actinomycetes (kg/ha)